Variability of the Meridional Overturning Circulation (MOC) in the 1992-2007 ECCO2 Synthesis

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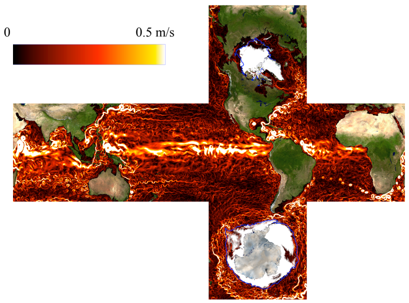
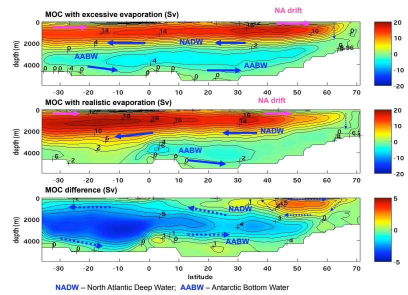


Introduction

There is considerable interest in estimating the strength and variability of the Meridional Overturning Circulation (MOC) because of its possible association with regional and global climate shifts. Here we examine the MOC in an eddying, 1992-2007 ocean state estimate produced by the Estimating the Circulation and Climate of the Ocean, Phase II (ECCO2, **http://www.ecco2.org**) project.

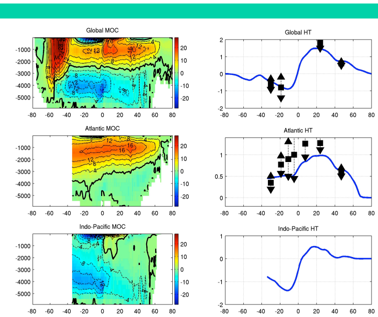
The ECCO2 solution, which is analysed here, is obtained on a cubed sphere, full-depth, global-ocean, and sea-ice configuration of the Massachusetts Institute of Technology general circulation model (MITgcm, **http://mitgcm.org**) with 18-km horizontal grid spacing. The figure to the left illustrated the grid and near-surface surface circulation of this solution.



Sensitivity experiments

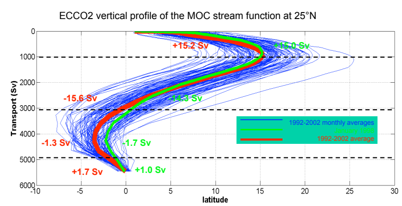
A first ECCO2 solution has been obtained using a Green's function approach. In addition to the optimized solution, the ECCO2 project makes available upwards of 80 forward model sensitivity experiments, which were used for the Green's function optimization, and which explore the model's response to different surface boundary conditions, initial conditions, horizontal and vertical mixing parameters, sea-ice model parameters, and to the addition of various sub-grid scale parameterizations.

For example, the figure to the left displays the impact on the strength and structure of the MOC of excessive (top panel) versus realistic (middle panel) evaporation at high latitudes.



Time-mean meridional streamfunction and heat transport

Time-mean of 1992-2007 global (top row), Atlantic (middle row), and Indo-Pacific (bottom row) meridional streamfunction (left column, Sv) and heat transport (right column, PW). The squares with error bars are estimates from *Ganachaud and Wunsch* (2002).



Meridional transport (Sv) in depth classes across 25°N as measured in a Jan-Feb 1998 cruise (Bryden et al., Nature, 2005)

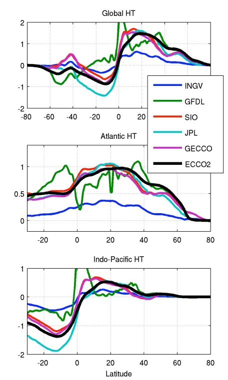
Shallower than 1000 m	+16.1
1000 – 3000 m	- 12.2
3000 – 5000 m	- 6.1
Deeper than 5000 m	+ 2.2

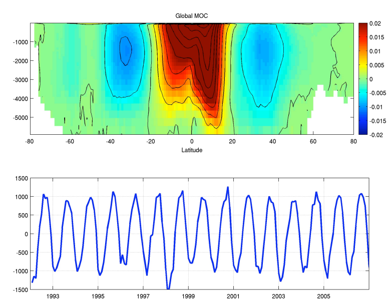
Comparison with in situ observations of the MOC at 25°N

The figure compares ECCO2-derived North Atlantic MOC at 25°N with hydrographic data. The North Atlantic MOC is highly variable and, therefore, it is difficult to infer the time-mean state of the MOC from synoptic measurements.

Comparison with other ocean data syntheses

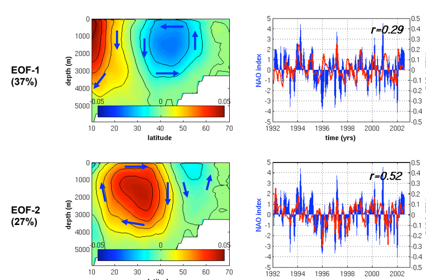
Comparison with meridional heat transport from other ocean syntheses that contributed to the CLIVAR/GODAE Global Synthesis and Observations Panel (GSOP, **www.clivar.org/organizations/gsop/gsop.php**).





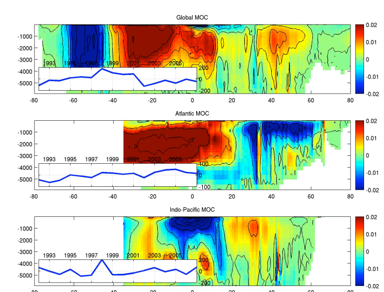
Global MOC variability

The first EOF (top panel) and corresponding time series (bottom panel) of the global MOC from the monthly-mean, 1992-2007 ECCO2 solution. This mode of variability explains 31% of the total variance and it is dominated by the annual cycle. Most of the variability occurs in the tropics and it is dominated by the Indo-Pacific Ocean. The Atlantic Ocean displays different characteristics: less variability but strong intra-seasonal signal superimposed on the annual cycle (see figure to the right) .



Atlantic MOC variability

EOF-1 of the Atlantic MOC shows a pattern associated with seasonal variability. EOF-2, along with intra-seasonal changes, also exhibits inter-annual variability. The variability of the EOF-2 pattern, computed from monthly MOC fields, is found to be correlated with monthly North Atlantic Oscillation (NAO) indices. The positive/negative NAO phase is associated with strengthening/weakening of the subtropical and subpolar cells of the MOC.



Interannual MOC variability

The first EOF and corresponding time series of the global (top panel), Atlantic (middle panel), and Indo-Pacific (bottom panel) MOC from the annual-mean, 1992-2007 ECCO2 solution. The Atlantic Ocean is the major contributor to the global MOC inter-annual variability.

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